Network and Communication Technologies; Vol. 5, No. 1; 2020
ISSN 1927-064X E-ISSN 1927-0658
Published by Canadian Center of Science and Education

Bernardo Autonomous Emotional Agents Increase Perception of VR Stimuli

Erik Geslin Ph. D[1,] Olivier Olivier Bartheye Ph. D[2], Colin Schmidt Ph. D[1], Katy Tcha Tokey Ph. D.[1], Teerawat Kulsuwan[2], Salah Keziz[2] & Tanguy Belouin[1]

[1] Arts et Métiers ParisTech, LAMPA, 2 Bd du Ronceray, 49000 Angers, France

[2] Ministère de la Défense Ecoles de Saint-Cyr Coëtquidan - 56381 GUER Cedex, France

Correspondence: Erik Geslin, Professor UCO Laval 3Di, MUTANUM Team, 25 rue du Mans, 53000 LAVAL, France. E-mail: e.geslin@ucolaval.net

Received: October 23, 2019 Accepted: December 11, 2019 Online Published: January 6, 2020

doi:10.5539/nct.v5n1p11 URL: https://doi.org/10.5539/nct.v5n1p11

Abstract

Video games are high emotional vectors. They play with the emotions of players by eliciting and increasing them. The importance of the induction of basic emotions has been a long forestay and is favoured by video game publishers, as they are quite easily mobilized. Video game publishers look to produce more complex social emotions like empathy, and compassion. In games framework with narrative context, designers frequently use cinema ~~movies~~ methods, like cinematic non-interactive Cutscenes. These methods temporarily exclude the player from interactivity to leave his first viewpoint view and move the camera focusing on the narrative stimuli. Cutscenes were used abundantly and are now rejected, the new development wave is often trying to develop in a "zero cinematic" way. For the same reason, cinematics are also not usable in new Virtual Reality. If VR games and simulations provides a high level of presence, VR environments ~~needs~~ certain rules related in particular to the continuation of free will and the avoidance of possible Break in Presence. We propose in this paper a concept of Emotionally Intelligent Virtual Avatars, which when they perceive an important narrative stimulus, share their emotions through, gestures, facial nonverbal expressions, and declarative sentences to stimulate the player's attention. This will lead players to focus on the narrative stimuli. Our research studies the impact of the use of Bernardo Agents Emotional Avatars involving n = 51 users. The statistical analysis of the results shows a significant difference in the narrative perception of the stimuli and in Presence, correlated to the use of Agents Bernardo. Overall, our emotional Agent Bernardo is a unique concept for increasing the perception of narrative stimuli in virtual environments using HMD, and may be useful in all virtual environments using an emotional narrative process.

Keywords: autonomous agent, cognitive architecture, emotion and cognition, emotional NPCs, computational modeling, video game, virtual reality, narration, stimuli perception

1. Introduction

Over the last ten years, video games have started a narrative emotional revolution enabled by authors like Eric Chahi, David Cage, Peter Molyneux. Whilst Virtual Reality had been essentially techno-centric and often focused on aspects of pure simulation. Currently, VR in video games, such as in Cyber therapy also uses many narrative scenarios to improve the user's experience. Many video game producers perceive the great interest of these headsets in terms of immersion and generously invest in the emerging market of VR video games. However, the narrative and filmic models commonly used in video games, are culturally inspired by film models. These techniques called "Cutscenes" and "Cinematics" leave no room for interactivity, they even replace it.

Many video games use these methods in excess, and they promise to players the opportunity to experience an extraordinary emotional adventure, but ultimately leaving them disappointed, incapable of any real interaction. If this narrative model of "Cutscenes" can suit a medium which uses in most cases a third person view, it has no place in a HMD first person view mode because its use may generate "Break in Presence" (Slater, 2002; 2003) and leave the user's immersion (Geslin, 2013). Break In Presence is generated by all kinds of pauses in the interactive process. Interactivity is possible only by the exacerbation of free will. Without free will, there is no interactivity and no immersion says Philippe Fuchs, he previously defined Virtual Reality as: I2 Immersion + Interaction (Fuchs, 2006). In a narrative video games context, "Cutscenes" allow to focus the attention of players on particularly important narrative stimuli, for understanding the whole dramatic plot. If during the game, the player must absolutely perceive a dramatic event like an explosion occurring at a hundred meters of his avatar, because of the use of cutscenes, he suddenly loses his free will, the camera follows the avatar, and leaves his initial position to move to the explosion and show this cinematic in the most graphic and aesthetic ways. The player has then no possibility to interact with the system. Immersive systems using HMDs do not seem appropriate to use with the methods of "Cutscenes", as these, generate more numerous "Break In Presence" (Geslin, 2013) but so far the necessity to focus the player's attention on dramaturgical events is identical to those of other video games.

We propose to use natural vectors to focus the attention of the players on the narrative stimuli. In an ecological context when a group of people faces a dramatic event as in an attack, subjects have collected information during the dangerous nature of the stimuli, consciously and unconsciously will seek to share this information with other persons. This sharing of sensitive information with the other group of subjects is one of many social systems that enabled the survival of our species. Recent research has shown how emotions are a collective property of groups, and emphasizes the influence of collective emotions (Barsade, 2002; Bartel & Saavedra, 2000; Duffy & Shaw, 2000). In order to share this information humans, like many animals use their facial expressions but also their body gesture language (Ekman, 1978).

We suggest creating Emotional and Social AAs (Autonomous Agents), able to perceive narrative stimuli of the virtual environment, and share them with the help of their facial expressions, body language, and imperative sentences to bring information to direct the gaze and attention of players to essential narrative stimuli and enhance the understanding of the dramatic conundrum.

The Bernardo Agent system is a new type of Computational Model of Emotions CMEs for AAs specifically in a virtual environment. The importance of CMEs has been illustrated in many research papers (Samsonovich, 2013; Rumbell, 2012; Ziemke & Lowe, 2009; Broekens, Hudlicka, & Bidarra, 2016). These agents appointed Bernardo Agents in reference to Bernardo the character from the Zorro TV series (Disney's, 1957) are positioned in the player's field of view and will express facial emotions or gesture expressions.

Several studies have shown that in virtual environments users have the same sensitivity for recognizing facial expressions of avatars (Jackson, Michon, Geslin et al., 2015) when they are created according to the FACS model (Ekman & Rosenberg, 1997). Bernardo agents use the coding of FACS to express their facial emotions and are able to share emotions with the players. The sharing and understanding of emotional expressions through the role of species conservation have been highlighted in numerous researches (Darwin & Prodger, 1998; Gallese, Keysers, & Rizzolatti, 2004; Damasio, 2008). Our hypothesis proposes that the use of emotional and social EAAs, Emotional Autonomous Agent (Wooldridge & Jennings, 1995; Rodríguez et al., 2016) called Bernardo allowed HMD video game players or VR users to perceive a greater amount of narrative stimuli and thus increased their immersion in terms of Presence (Slater, Usoh, & Steed, 1994) and emotions (Geslin, 2013). Those Bernardo agents permit them to avoid using narrative techniques as Cutscenes that generate breaks in Presence (Slater, 2002).

1.2 UX Measurement in VR

In Virtual Reality as in video games, the use of narration increases the immersion of users or players. Dramaturgy concepts are based on a finished story. This leaves little to chance, and when it is interactive, its multiple paths are widely anticipated. The narration allows the player to give way to the pleasure of Mimicry, it allows identification with the avatar, and gives the opportunity to experience many adventures. Interactivity is based on Alea, chance, pleasure linked to the mastery of a VR or Video Game system, it's also partly generated by the player's ability to exercise his skills and his capacity to anticipate in the mastery of a random system. Narration and interactivity, Mimicry and Alea, allow the creation of rich and complex virtual universes (Caillois, 2015). However, if these items are complementary, they are also frequently opposed, both in their size and in their implementation. Video games are constantly evolving. They follow the technological and societal changes, and it also depends on the age of their commercial targets. The average age of players of video games is increasing due to the aging of Generation X who were the primo users of this media. Gamers are also consumers of many emotional narrative medias such as cinema films and literature. Players and VR users therefore require more interactive emotional experiences, but paradoxically their free will may induce a loss of attention to the narrative stimuli introduced by the designers.

Directing users' attention to narrative stimuli in a natural way is therefore an important challenge for the future of the User eXperience (UX) in VR and in Video Games. UX in VR, as well as in any other system, implies a number of "perceptions and responses" (e.g. emotional, cognitive, behavioral, judgmental) from the user when he interacts with the Virtual Environment (VE). These perceptions and responses need to be collected in order to verify the user's state of mind during or immediately after his experience in the VE. Furthermore, the identification and analysis of the user's perceptions and responses (with measurement methods) will help validate our hypothesis (i.e.

H: the VE with the Bernardo avatar improves the user's experience in terms of presence, immersion and flow compared to the VE with the classic avatar).

The UX is the main component a VE designer needs to measure in order to find out if the user is satisfied and if his needs while he is interacting with the VE are met. There are several methods to measure the UX, either by subjective or objective methods. Subjective methods such as interviews, focus groups or questionnaires are often used to collect the user's subjective point of views or opinions. We used the Presence Questionnaire (PQ) defined by Bob Witmer and Michael Singer (Witmer & Singer, 1998) and the SUS, Slater-Usoh-Steed Questionnaire (Usoh et al., 2000) to measure the immersion and the sense of presence of the user, and we used the Flow questionnaire Flow4D16 (Heutte, 2011) to measure the quality and the fun the user perceives during his experience in the VE.

2. Bernado EAAs Architectures

2.1 Emotional Autonomous Agent

It is now recognized that the different human behaviors are the result of cognition and affective functions. A multitude of theories and models of the disciplines of psychology and neuroscience try to explain the underlying mechanisms of systems. In the area of Artificial Intelligence (AI), the challenge of creating Emotional Autonomous Agents (EAAs) with coherent behaviors draws on these different areas of research. Computational Models of Emotions (CMEs) are softwares inspired by models and theories capable of producing internalized emotional behaviors of EAAs. The Bernardos Agents are therefore Emotional Autonomous Agents (EAAs) operating on the basis of a CMEs based on principles derived from the disciplines of psychology and neuroscience. The links between the activation of emotions and the internal perception of stimuli are demonstrated in many works (Damasio, 1994; Gros, 2010).

It has been shown that humans react in response to the salience of stimuli and adapt their emotional responses in a non-conscious or conscious reflexive way, depending on these stimuli but also on the social context in which they occur (Clore, 2009; Loewenstein, 2003). The objective remaining to adapt the emotional reactions to the best to ensure the survival and well-being of the individual or group. It is also well known that the emotional states of each individual will determine their facial, verbal as well as body postures expressions (Scherer, 2003; Planalp, 1996). The Bernardo Agents also define the hierarchy of their emotional reactions as a function of the Stimulus salience (distance, LoS, occlusions). The nature of the expressions of their emotions is also related to the context and proximity of other individuals. In the field of IA most of the CMEs studied comparatively in the works of Luis-Felipe Rodr□guez and Felix Ramos have the same elementary structuring. In the first place, emotional stimulus is evaluated, secondly emotional elicitation and finally an emotional response, which can be verbal, facial, or bodily (Rodriguez & Ramos, 2014).

Bernardo Agents Emotional architecture is defined by Appraisal theories (Fridja, 1989; Roseman, 1990), appraisal theory suggests that an individual's emotions are directly related to the different contexts encountered, and that the goals, plans, and beliefs of the individual may change completely depending on the different elements such as situation, objects and agents present in this context. We have also introduced a dimensional notion in the CME of our Bernardo EAAs, which is based on an interpretation of arousal and valence of stimuli referred to the Russel circumplex model (Russel, 2003). We have therefore developed our own model of CME rather than the use of CMEs already established as EMA (Marsella, 2009), PEACTIDM (Marinier, 2009) or WASABI (Becker-Asano, 2010). As in each of these CMEs, we use cycles of analysis that allow, in the final phase, to modify the reaction of other agents, depending on the decisions taken, depending on the type and threshold of the dialogue skills and the facial expressions used. However, like other analysis (Scheutz, 2004; Rodriguez, 2014) we have developed the CME of the Bernardo Agent with the aim of a robust and flexible system, specifically aimed at the production of interests on narrative emotional stimuli specific in VR. We have used the potential of Behavior Tree (BT) a kind of Hierarchical FSM (Finite State Machine) with modular nodes to design our EAI architecture (Figure 1).

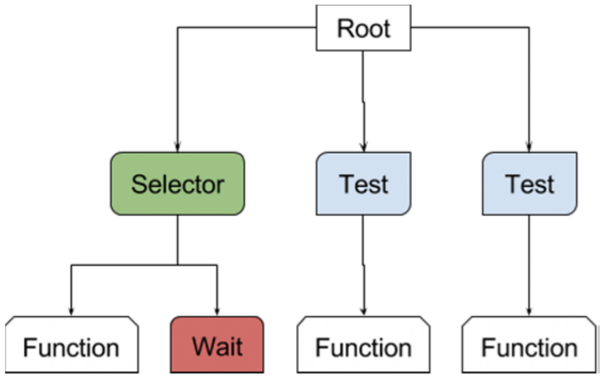

Figure 1. Behavior Tree Diagram (Unity3D.com).

2.3 Agents and Architectures

Algorithmic regarding to Bernardo EAAs means actually the ability to model the interaction of emotion and cognition in agent architectures so that EAAs are capable of generating emotional states and displaying believable emotional behaviors (Scheutz, 2004). We chose a model able to implement a collective intelligence for Bernardo EAAs based on their emotion propagations. Each individual influences the group impacted by the stimulus and conversely that group influences each of its individuals (note that such an interaction can be depicted by the double link between classes EAA_BernardoAgent and EAA_BernardoAgentList in the Class diagram below (Figure 02)). Such a mutual interaction permits to model a chain reaction leading finally to a panic behavior in the case of a group impacted by a stimulus. According to this, since any agent has common intrinsic properties and individual behaviors, an abstract model of an autonomous agent leads to define an EAA_BernardoAgent class, using their internal description as attributes (internal values) and their interactions with other agents as agent methods. That way, agents are implementable objects, i.e., particular instances of that EAA_BernardoAgent class. Collective intelligence is implemented according to the compound class EAA_BernardoAgentList whose attribute named agents is the list of EAA_BernardoAgent objects.

Dynamic subsets forming an impacted group of agents are extracted according to the impact of the stimulus on one or more Bernardo Agents and they form a temporary instance of the class Impacted_EAA_*BernardoAgentGroup*. The methods defined for that class implement coordinated autonomous agent emotions applying on a subgroup of those. In particular, new agents can be inserted by the method *addNewAgent*, the group emotion can be initiated by an agent using *propagateGroupEmotionsFromAgent*, and a complex computation of all emotions interactions is performed by the method *computeAllPropagations* for all agents in that group.

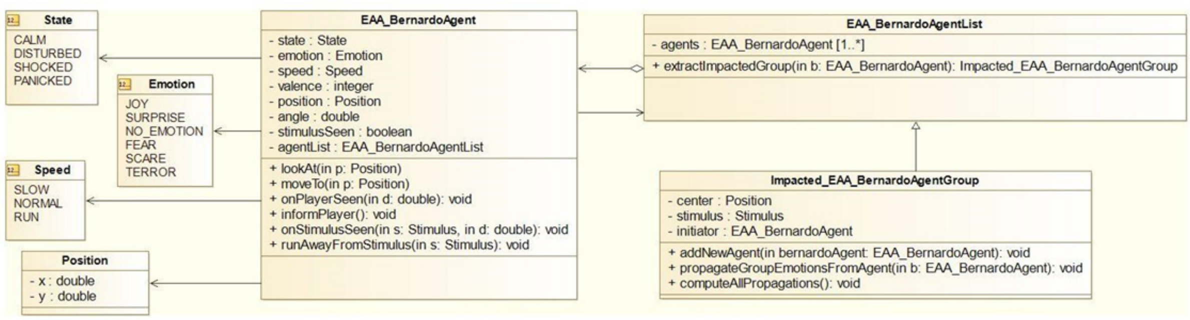

Figure 2. EAA_BernardoAgent Class Diagram

One can note that, for every Bernardo agent, three distinct fear levels are set. This rich set of negative valence emotions is required in order to implement the propagation of a stimulus impact by at least three hits by agents (an emotion hit or a collision) leading to a group panic in a suitable response time. The aim is to provide significant fear rising edges and fear falling edges in order to manage the group response impacted by a stimulus. That way, multiple parameters can be considered namely, the distance to the stimulus which depends on the run speed, the size of the group and the current emotional fear level of each autonomous agent.

2.3.1 Game Engine Implementation

The global class diagram including the game engine, the player, the list of stimuli and the list of emotional agents is the following (Figure 3):

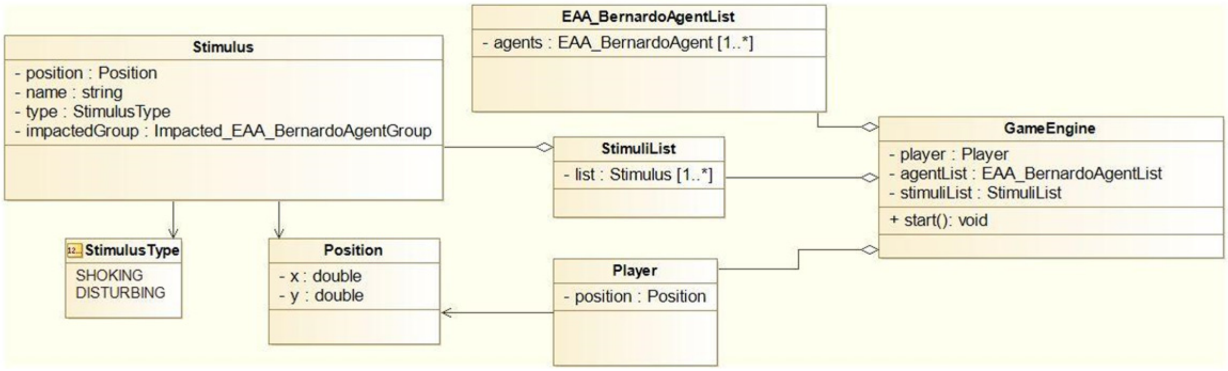

Figure 3. Game Engine Class Diagram

If one adds the Player class and the compound *StimulusList* class according to their respective positions in the game (position is defined as an intrinsic attribute), then the static (unique) *GameEngine* class fires events triggered by the occurrence of an instance of the Player class in the neighborhood of one of the elements of Stimulus object list. The general algorithm for the game is defined below (Figure 4).

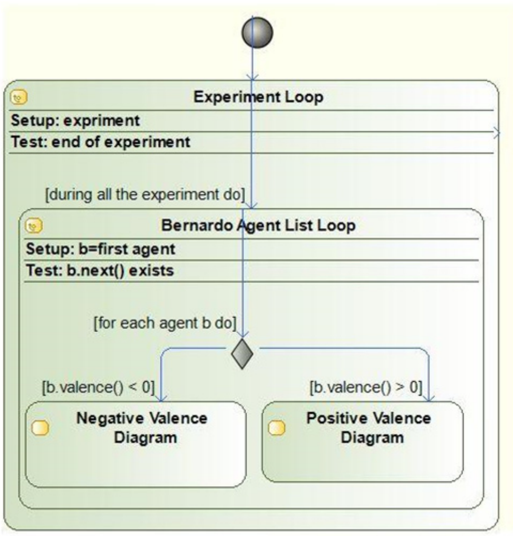

Figure 4. Game Engine Activity Diagram

Once a stimulus is triggered, an EAA_BernardoAgent instance reacts as moving towards the zone where the event occurs and behaves according to his generated emotions with respect to the detected stimulus; recall that this stimulus is not necessary identified if it is not in his LoS (Line of Sight). Individual behaviors are expressed according to activity diagrams depending on the EAA_BernardoAgent emotional valences (note that nothing is performed for an agent in case of a null valence).

2.3.2 Positive Valence

Positive valence is taken to be a nominal state with controlled behavior; consequently, in the case of a positive valence, the diagram is quite simple and will finally end by a gathering around the meeting point close to the stimulus (Figure 5).

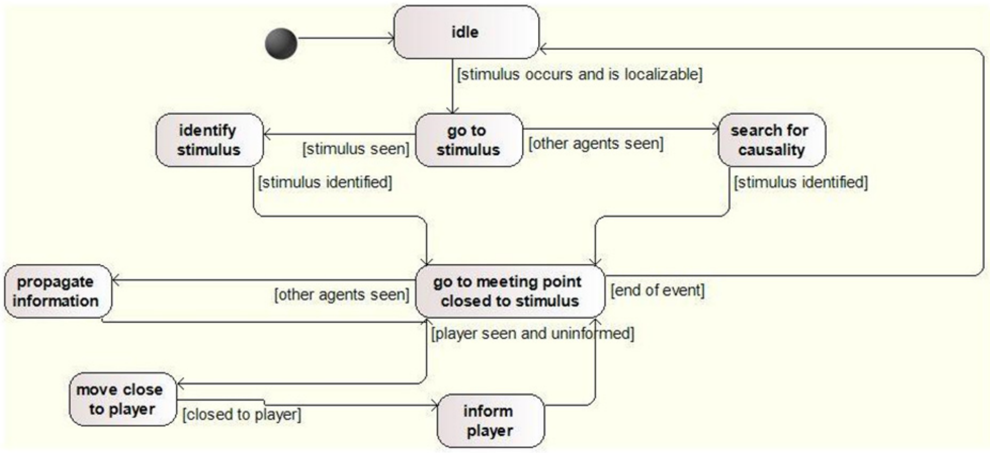

Figure 5. Positive Valence

2.3.3 Negative Valence

In the case of a negative valence, some chaotic situations may occur; that is, the individual and the collective behavior is much more complicated to model; if the stimulus is seen, the immediate reaction is to go away; if the stimulus is not in the line of sight of an agent, this agent must take into account fear emotions from impacted agents and eventually panic scenes in order to define the right behavior to apply and consequently to contribute mechanically to the group behavior (Figure 6). When a stimulus is identified by an agent and other agents are seen, then an emotion propagation mechanism is shared between these agents forming the closed group impacted by the stimulus.

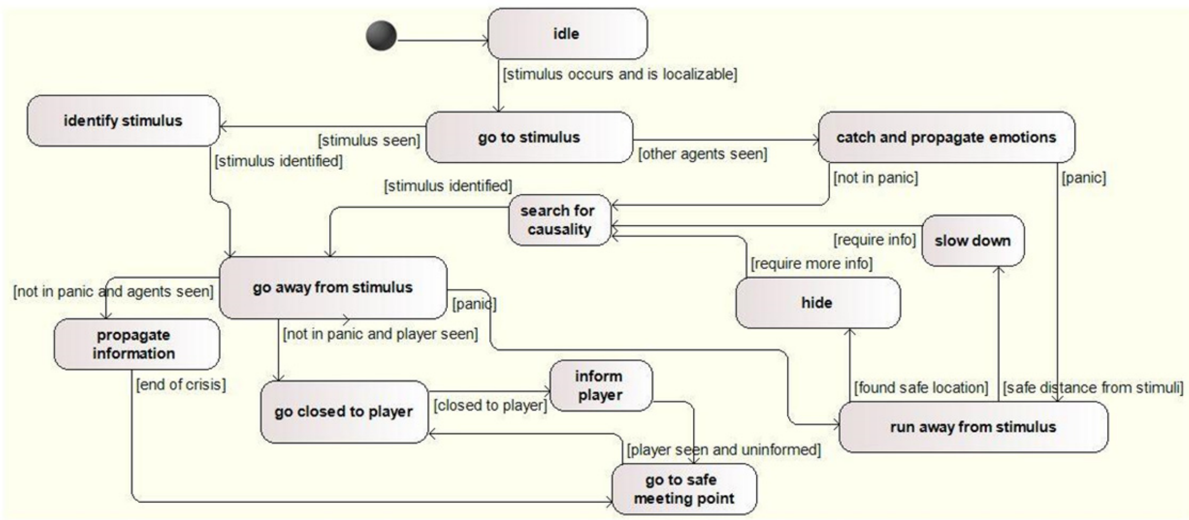

Figure 6. Negative Valence

According to the behavior that has already impacted other agents, then, depending on their mood, they can run away due to a generalized panic or they can search for causality in order to be able to interpret this stimulus since it is not yet in their LoS.

2.3.4 Causality Search

Searching for causality has two roles: the first one is more internal, that is, tune the right emotion according to the stimulus whereas the second one is social, that is, being able to inform others. The causality search is a sophisticated mechanism depending on three factors: 1) the panic intensity corresponding to the mental state of the agent and directly expressed by the runaway speed, 2) the emotional level of the agent and 3) the number of Bernardo agents in presence (more than three leads to crowd effects).

Causality search is characterized by the time spent to find a visual interpretation of the stimulus and cannot hold when an agent is in a panic state. One can roughly define panic propagation as an amplification effect depending on valuations on each agent sphere forming the impacted group: the number of agents located inside that small sphere whose centre is the position of the agent and levels of fear inside that sphere. In case of panic, an agent runs away in the opposite direction of the stimulus and after some time and some collisions between other agents, and after a while he will finally leave the group dynamic and find a safe position. Note that, in a group, one should as well include atypical behaviours in a low but not null rate; typically, a few number of individuals should fight against a terrifying stimulus instead of fleeing. At this stage, it is important to note that if the EAA_BernardoAgents act autonomously, they are also conditioned to act more precisely in respect to the user's experiment. They systematically go before the exchange of contextual and emotional information with the user by trying to position themselves in his LoS in order to motivate a reaction on his behalf.

3. Designing Bernardo EAAs

3.1 Morpho Physiological References

Humans quickly formalize emotions based on the morphology of the faces of people they meet. Our Bernardo Agents must naturally inspire confidence so as not to produce an initial rejection of emotion induction model. The morphophysiological appearances count because some facial features are useful in the development of adaptive behavior so that even traces of these qualities can produce an emotion (overgeneralization theory). The theory of overgeneralization, remains today the most used to explain why we are so sensitive to other faces. Many studies show that the valence of the context (positive or negative in the sense of survival, or welfare), but also the relationship between behavior and perceived faces, and the social objectives of the observer are also important. The influence of morphophysiology on our emotional behavior is known and scientifically very referenced: Whether in the context of hedonism to define if a sexual partner is genetically adapted (Zebrowitz, 1997, 2003), our value judgments (Eberhardt & Davies, 2006; (Zebrowitz & McDonald, 1991), as in the prediction of legislative votes (Willis & Todorov, 2006), the attraction or rejection of the faces that we meet, the need to quickly detect a hostile person. The ecological hypothesis is more contextual, and is more accessed on the idiosyncratic aspects of each individual, in this theory, kind faces are positively associated in our lives depending of our experiences (Zajonc, 1968; Zebrowitz, 1996). It is likely that our instincts work on both procedures, those of our own experiences and those of Familiar Face Overgeneralization (FFO). We use these two theories in our approach morphophysiological Characters design Bernardo agents. Emotional perception of faces is the same regardless of the cultures (Kramer et al., 1995) and the rejection of facial defects are a constant phenomenon of Overgeneralization. If "ugly is bad" "beautiful is not Often good" (Griffin & Langlois, 2006), beauty can sometimes be seen as a ploy hiding misalignment, we are not talking about some of the "beauty of the devil "however there is a tendency to attraction related to sexual dimorphism, and the more the women have female traits, they become attractive and more men are male, they become seductive. However, in the past, in some societies where survival of the family was linked to the intellectual capacity and social ascension than to the resistance to nature, the canons of beauty and attraction of the men go to a smaller sexual dimorphism, men may be less masculine. Characters presenting the greatest differences in their sexual dimorphism (the more masculine or more feminine), are not necessarily considered the best (although still attractive).

Indeed, the notion of beauty could be a concept of negation, which finds expression in the avoidance of the ugly (Grammer et al., 2002). Faces of medium lines (means spacing eyes, nose and mouth, ears shape, etc.) are considered unconsciously as evidence of greater genetic diversity, and thus better health, especially if they are of great symmetry (Scheib et al., 1999). The face of a Bernardo Agent could not be Babyface kind (child's face, baby, eyes wide apart raised eyebrows, small nose and round face, low facial placement on the head, high forehead and small chin (Montepare & Zebrowitz, 1998), when that face is worn by women, it is attractive. but it is perceived as less intelligent and socially unreliable when it is worn by a man (Berry & McArthur, 1986). This choice is highly correlated with the sexual kind of Bernardo Agent.

We develop in our experience one male character design (Figure 7), but if it was the female gender our approach would have been different. Baby face in children unconsciously arouses naivety and generates great empathy, it activates more brain activity in the observer (Winston et al., 2002). Children and young women with babyfaceness are considered honest and weaker. Morphophysiology is perfect to enhance empathy in such Bernardo agents. Several studies show that low eyebrows are associated with dominant characters in Western cultures (Keating et al., 1981). Insofar as the Bernardo Agent will use directive sentences for directing the LOS of users, we used this physiological feature. In the same way, temporary perception of facial expression is interpreted as a general trait of character (Secord, 1958). A person with an angry face is not seen only angry, but mainly as a dominant person

(Keating et al., 1981). For the design character of Bernardo Agent, we define a neutral expression slightly associated with anger. As the more mature faces arouse intellectual competence and social power (Montepare & Zebrowitz, 1998), the age of Bernardo Agent can promote the perception of paternal benevolence (Broverman et al., 1972). The Bernardo Agent of our experiment is between 50 and 60 years old, he can promote the perception of paternal benevolence (Broverman et al., 1972).

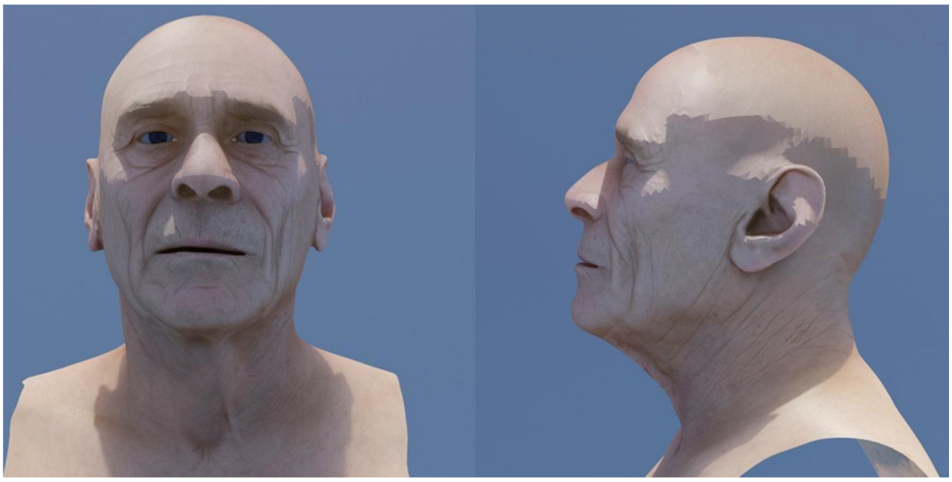

Figure 7. Bernardo's neutral facial expression of emotions, P. Ekman FACs Based

The foreign faces in our ecosystem whether social or racial family create a negative emotional response (Zebrowitz, 1997; Zajonc, 2001). Theory suggests that a face associated with a person of the collective group, will be judged unconsciously positively. We developed a Bernardo Agent with Indo-European physical features consistent with our n: 51 testers from academia West European context. The Bernardo Agent is large enough, his saturated skin gives him a natural aura in the sometimes-disturbing context of the experiment. His face is very masculine but the Bernado agent is not especially beautiful, he has coarse features, but these features are not those of incapacity (Griffin & Langlois, 2006), the Bernardo Agent has very thick eyebrows which according to the evolutionary theory are there to protect eyes when there is a fight, they are hardly noticeable except in times of intense emotions. He has thick nasolabial muscles. A wide and high forehead. Everything in Overgeneralization theory is to bring the player to want the protection and assistance of Bernardo Agent.

3.1 FACS, Verbal and Nonverbal Expressions of Emotions

High-quality emotion expression animations have been designed based on the Facial Action Coding System (FACS), comprising 45 facial muscular movements and 10 head movements (Hager et al., 2002; Ekman & Friesen, 1978; Hjortsjö, 1969). Based on the work previously done in the context of the generation of realistic avatars simulating pain (Jackson et al., 2015), we have developed a process of generation of avatars with expressions of emotions developed on initial photogrammetric scanned model realized with ReMake® (Autodesk, 2016). This approach was previously used in the "Palimpsest" project of Takashi Torisu, he suggests that the quality of the reconstruction of the avatars could influence the feeling of presence In VR (Torisu, 2016).

The 3D model in high resolution generated in photogrammetry is then applied by deformation in projection with Wrap3® (Russian3Dscanner, 2016) on a low-resolution 3D model made in retopology and more adapted to real time 3D environments for Virtual Reality. This technique allows to produce many avatars scanned by photogrammetry and using a single 3D base in low polygonal resolution on which are applied in the software 3DsMax® 2017 (autodesk, 2017) the morphers of expression of emotions based on the The FACS model (Figure 8). Morphers also called Blend Shapes (morph target animations) are convex combinations of n base vectors and mesh, forming the same topology. The different movements of the vertex points in xyz space make it possible to create animations of shapes. Facial muscle contractions and relaxations create variations that are encoded as Actions Units (AUs). Each facial muscle group is defined by a AU number, the combination of some of these different groups create emotional expressions.

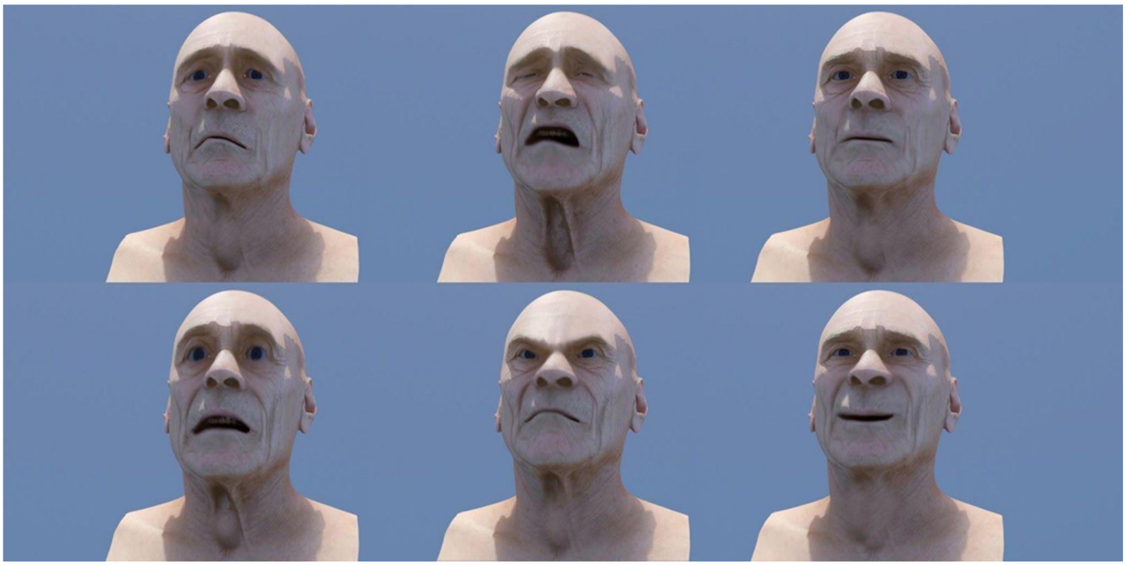

Figure 8. Bernardo’s facial expression of emotions, P. Ekman FACs Based

4. Method

4.1 Participants

We used the G*Power 3.1 tool to determine the size of the two groups of participants required for our study. For Test family: T test, Means: difference between two independent means (two groups). For $n1 \neq n2$ and $M1 = 0$, $M2 = 1$, $SD = 1$ for each group. Input parameters: Effect size $d = 1$, $p < 0.05$, power err prob 0.95, ratio $N2 / N1 = 1$. G*Power 3.1 gives this estimate: Critical $t = 1.680$, Df 44, Sample size group 1 = Size group 2 = 23, Total sample size = 46, actual power = 0.954.

On reading these estimates, the participants in this study were $n = 51$ adults ($n = 13$ women) recruited through advertisement on the campus of UCO University, Laval’s Campus. They were aged between 17 and 46 years ($M = 22.0$ years; $SD = 5.15$ years). Exclusion criteria consisted in having a neurological or psychiatric disorder, or having previously participated in a study on Bernardo Agents. Written informed consent was obtained from all participants. At the call of their name the participants enter an isolated room and sit on a chair in front of a computer HP 480, CPU Core i7, GPU Nvidia 1080. This one is equipped with a HMD Oculus CV1.

Initially the participants complete a pre-experimental questionnaire in which they record their: first name, name, age, sex. They also read and sign the consentement agreement. A research engineer gives them orally the instructions to follow the virtual path that they will discover before by using the device of the Xbox360 controller. Participants are advised that they are free to stop the experiment at any time at their request. He also advises them to naturally move the head once the HMD is positioned on their head. The virtual environment looks like a giant maze in which users wander in a linear way. In order, not to introduce parasitic emotional and attentional stimuli, we chose not to use a realistic environment. The walls here are covered with a checkered orange texture that buckles indefinitely (Figure 9).

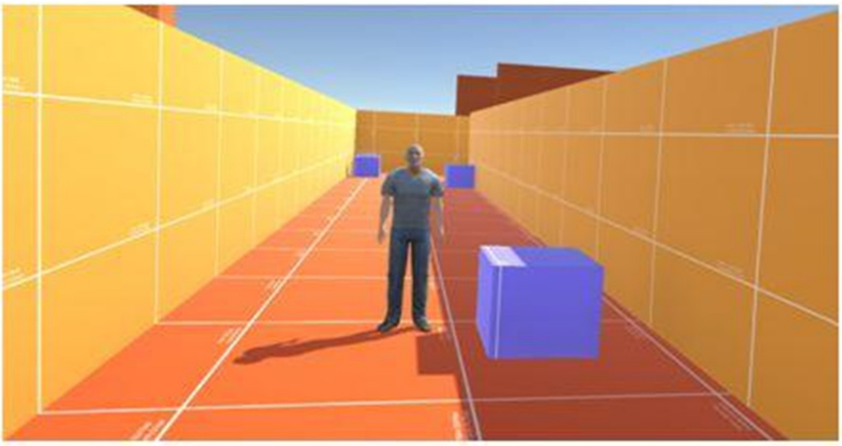

Figure 9. Bernardo Agent in the maze context

13 Narrative stimuli were randomly disseminated over the course of about twenty minutes (Figure 10). 4 of these stimuli are of positive valance, 6 are shocking and 3 scary. We define frightening stimuli by their nature to engage "virtually" the physical integrity of the participants, such as the attack of an animal. Shocking stimuli are visually impressive such as the distant explosion of a building or the suicide of a character, but these are not physical hazards to the participants. Positive valence stimuli are likely to arouse surprise as the magical vision of a superhero. All the stimuli appear outside the direct participant's field of view, the stimuli triggers are activated by the passage of the participants and appear on their backs. Participants were randomly divided in two groups.

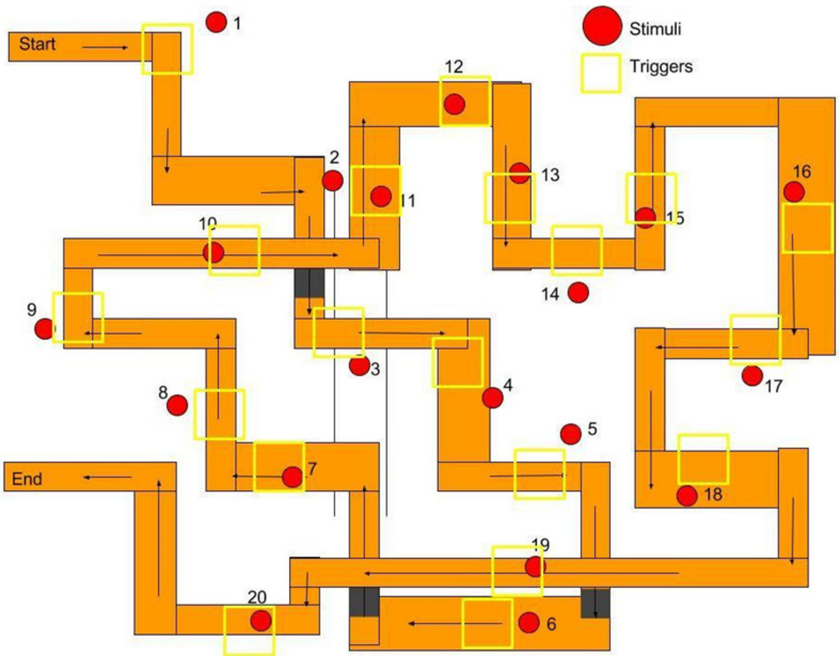

Figure 10. Bernardo Agents Stimuli Maze Map

The "Bernardo's Group" visualizes the experimentation with all active Bernardo agents, when they visualize a narrative stimulus they seek to share their experience with the other avatars and specifically with the participant. Bernardo Agents then use their facial expressions and their body gestures to share information. They also include in their oral discourse imperative sentences, in addition to exclamatory and declarative sentences. The second group is called "Control Group". Participants associated with this group experience the same stimuli as the participants in the "Bernardo's Group", but all of Bernardo's experimental agents are deactivated, however they express emotions by visualizing stimuli but do not actively share them, they do not voluntarily move to other avatars or participants. They express their surprise with declarative and exclamatory sentences, but they do not use the directive or imperative mode. Once the virtual path has been completed, participants respond to the various post-experimental online questionnaires. These are composed by: the subjective semantic questionnaire of perception of the narrative stimuli, the SUS, the SSQ and the Flow4D16.

5. Results

The results show very high means of recognition for the "Bernardo's Group" ($M = 9.36$, $SD = 2.16$) and low for the Control Group ($M = 3.88$, $SD = 2.5$). The correlation of the averages between the two groups is high and significant, the analysis of the data shows that there is a relationship between the presence of the Bernardo Agents and the quality of the perception of narrative stimuli ($r = 0.71$, $p < 0.00001$) (Figure 11). This analysis is confirmed by the T test ($t = 8.383$, $dl = 49$, $p < 0.000001$). A Levene test of homogeneity of the variances allows to reject the null hypothesis ($F = 1.183$, $p < 0.282$). One-way ANOVA reveals a significant effect of the use of Bernardo Agents ($F(12, 38) = 4.886$, $p < 0.000001$).

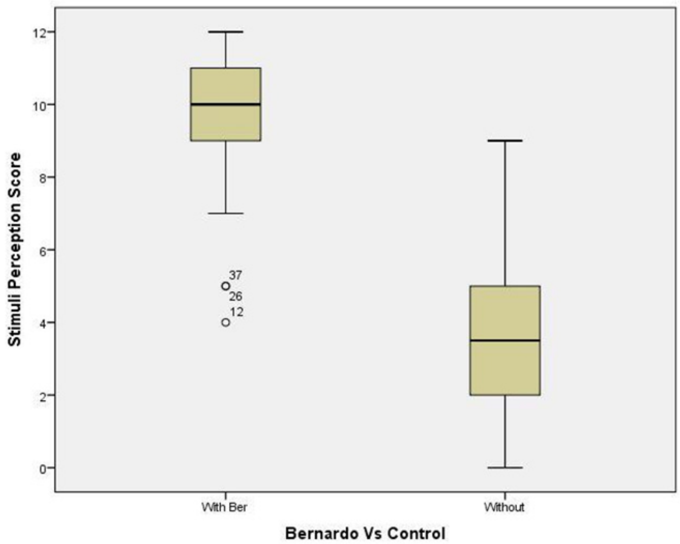

Figure 11. Stimuli Perception between groups, results

The results of data analyze show a difference in the perception of stimuli between men and women, perception of stimuli by women ($M = 5$, $SD = 3,266$), perception by men ($M = 7.11$, $SD = 3.593$). This difference is marginally significant T test ($t = -1.864$, $dl = 49$, $p < 0.068$). The effects of simulator sickness measured with the SSQ questionnaire do not appear to show any significant differences between the experimental groups with and without the Bernardo, Bernardo's Group ($M = 36.5$, $SD = 27.1$), Control Group ($M = 43.5$, $SD = 26.46$); T test ($t = -0.930$, $dl = 49$, $p < 0.357$). The One-way ANOVA does not reveal any significant differences, neither for the SSQ test nor for the Flow4D16 questionnaire. SSQ Score ($F(1, 49) = 1.899$, $p < 0.174$). Questionnaire Flow4D16 ($F(1,49) = 1,269$, $p < 0.266$). The feeling of presence found in the SUS questionnaire shows a significant difference between the two groups, Bernardo's Group ($M = 61.42$, $SD = 11.94$) Control Group ($M = 51.77$, $SD = 10.64$) (Fig.12), T test ($t = 3.050$, $dl = 49$, $p < 0.004$), One-Way ANOVA ($F(1,49)$ 9.302, $p < 0.004$).

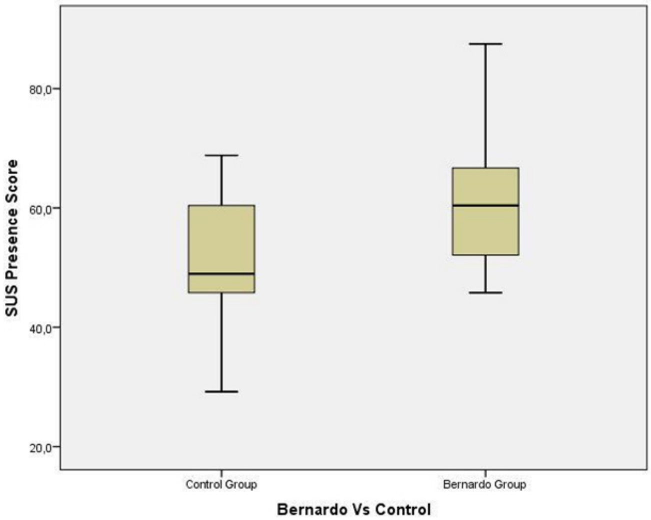

Figure 12. SUS Presence between groups, results

6. Discussion

The results of our research imply that important links exist between the use of Bernardo Agents and the number of narrative stimuli perceived by users. The group of Bernardo Agents users have deliberately or unconsciously focused their attention on narrative stimuli. After the experience, they are able to remember the perceived events, but also to contextualize them. There was a slight difference in perception between men and women, which was marginally significant, perhaps related to the fact that the Bernardo Agents were all men? It would be interesting to study the impact of the use of female Bernardo Agents on this category of users. We did not notice any significant difference between the two groups in terms of Motion Sickness but the average was quite high probably due to the cognitive incoherences generated by long travel using a joystick while sitting (D. R Mestre, 2014). If the SSQ questionnaire reveals a slightly higher average score for users of the Bernardo Agents group we associate it with a higher head motor activity when looking for stimuli. Finally, the results associated with the SUS presence questionnaire show the same significant difference between the Bernardo groups and the Control group as for the measurement of the number of narrative stimuli.

We can deduce that Bernardo Agents not only focus Virtual Reality HMD' users' attention on almost all stimuli, but they also increase the level of the user's sense of presence. This difference in levels of presence may be related to the cognitive loop described by Erik Geslin (Geslin, E. 2013). The more the users focus their attention on emotional events, the more they seem to let themselves have fun in their immersed world. Our experiment suggests that Bernardo's Autonomous Emotional Agents can be used in Virtual Reality applications using HMD headset to focus users' attention on narrative stimuli which are essential to the understanding of the scenario. Over and above this, the use of these same Bernardo Agents ultimately allows to significantly increase the feeling of presence and thus to more effectively immerse users in the virtual environment.

Overall, these validation experiments are encouraging and confirm the potential of Bernardo Agents for a large number of new experiments.

7. Conclusion

Our research was conducted in order to design and validate a powerful tool to significantly increase the quality of the processes of focusing on narrative stimuli for the users of Virtual Reality with immersive HMD. In a neutral framework without Bernardo Agents, most narrative stimuli are not perceived due in particular to the free will of the VR users. Simon has shown in early works (Simon, 1967) that emotions serve the crucial function of interrupting the natural cognition process when contextual unattended goals occur. Based on this deduction, we have shown through our experiments that it is possible to use the power of emotion interruption being shared to allow users to focus on narrative stimuli. The use of Bernardo Agents should allow video game designers, but also designers for training or learning VR simulation, to fill the impossibility of using processes like cut-scenes in Virtual environments with first-person view. These narrative methods are used to direct users' attention to important narrative events. The Bernardo Agents can replace these previous processes but also increase the sense of presence, which is essential for immersion in virtual environments. We have also integrated some Bernardo agents in the design of VR video game FATED (Frima Studio). By using semantic subjective questionnaires, we studied narrative stimuli quality perception, level of presence and sense of Flow Zone in two distinct groups. The first group tested an Oculus CV1 HMD version of the game without Bernardo Agents, and the second one used a Bernardo Agent version. In this study, the results have also shown how the use of Bernardo Software Autonomous Agent increases the perception of narrative stimuli. Our next developments and future experiments will integrate essential elements such as the IR (Infrared) eyes-tracking inside the HMD helmet. This is in order to allow greater coherence in the emotional attitudes of Bernardo Agents. We believe that it is essential to be able to interpret the user's gaze, but also to capture the expressions of facial emotions of the HMD helmet holder, in order to be able to deliver a response which would correspond with the context and the level of involvement of the user. Making the essential concepts of our Bernardo Agents tool available to the VR community is a priority for our team. Bernardo Agents will contribute directly to the increase in narrative quality in immersive virtual environments with HMD.

References

Barsade, S. G. (2002). The ripple effect: Emotional contagion and its influence on group behavior. *Administrative Science Quarterly, 47*, 644-675. https://doi.org/10.2307/3094912

Bartel, C. A., & Saavedra, R. (2000). The collective construction of workgroup moods. *Administrative Science Quarterly, 45*, 197-231. https://doi.org/10.2307/2667070

Becker-Asano, C., & Wachsmuth, I. (2010). Affective computing with primary and secondary emotions in a virtual human. *Auton Agents Multi-Agent Syst., 20*(1), 32-49. https://doi.org/10.1007/s10458-009-9094-9

Broekens, J., Hudlicka, E., & Bidarra, R. (2016). Emotional appraisal engines for games. In *Emotion in Games* (pp. 215-232). Springer, Cham. https://doi.org/10.1007/978-3-319-41316-7_13

Caillois, R. (2015). *Les jeux et les hommes. Le masque et le vertige*. Editions Gallimard.

Castellano, G., Kessous, L., & Caridakis, G. (n.d.). Emotion Recognition through Multiple Modalities: Face, Body Gesture, Speech. *Affect and Emotion in Human-Computer Interaction Lecture Notes in Computer Science*, 92-103. https://doi.org/10.1007/978-3-540-85099-1_8

Clore, G. L., & Palmer, J. (2009). Affective guidance of intelligent agents: how emotion controls cognition. *Cogn Syst Res., 10*(1), 21-30. https://doi.org/10.1016/j.cogsys.2008.03.002

Damasio, A. (2008). *Descartes' error: Emotion, reason and the human brain, Random House*.

Damasio, A. R. (1994). *Descartes' error: emotion, reason, and the human brain* (1st ed.). New York: Putnam Grosset Books.

Darwin, C. (1859). *L'origine des espèces*.

Darwin, C., & Prodger, P. (1998). *The expression of the emotions in man and animals*. Oxford University Press, USA.

Disney's, W. (1957). Zorro.

Duffy, M. K., & Shaw, J. D. (2000). The Salieri syndrome: Consequences of envy in groups. *Small Group Research, 31*, 3-23. https://doi.org/10.1177/104649640003100101

Ekman, P. (1992). An argument for basic emotions. *Cognition & emotion, 6*(3-4), 169-200. https://doi.org/10.1080/02699939208411068

Ekman, P., & Rosenberg, E. L. (1997). *What the face reveals: Basic and applied studies of spontaneous expression using the Facial Action Coding System* (FACS). Oxford University Press.

Ekman, P., & Friesen, W. (1978). *Facial Action Coding System: a Technique for the Measurement of Facial Movement*. Palo Alto, CA: Consulting Psychologists Press. https://doi.org/10.1037/t27734-000

Entertainment-Software-Association. (2014). *2014, Demographic, and Usage Data Essential Facts About the Computer and Video Game Industry*.

Fuchs, P., Moreau, G. et al. (2006). *Le traité de la réalité virtuelle, les Presses de l'École des Mines*.

Frijda, N. H., Kuipers, P., & ter Schure, E. (1989). Relations among emotion, appraisal, and emotional action readiness. *J Pers Soc Psychol., 57*(2), 212-228. https://doi.org/10.1037/0022-3514.57.2.212

Gallese, V., Keysers, C., & Rizzolatti, G. (2004). A unifying view of the basis of social cognition. *Trends in cognitive sciences*, *8*(9), 396-403. https://doi.org/10.1016/j.tics.2004.07.002

Geslin, E. (2013). *Processus d'induction d'émotions dans les environnements virtuels et le jeu vidéo, Ecole* *nationale supérieure d'arts et métiers-ENSAM*.

Gros, C. (2010). Cognition and emotion: perspectives of a closing gap. *Cogn Comput., 2*(2), 78-85. https://doi.org/10.1007/s12559-010-9034-7

Hager, J. C., Ekman, P., & Friesen, W. V. (2002). *Facial action coding system*. Salt Lake City, UT: A Human Face.

Heutte, J. (2011). *La part du collectif dans la motivation et son impact sur le bien-être comme médiateur de la réussite des étudiants : Complémentarités et contributions entre l'autodétermination, l'auto-efficacité et l'autotélisme, Université de Nanterre-Paris X.*

Hjortsjö, C.-H. (1969). *Människans Ansikte och det Mimiska Språket*. Lund: Student literatur.

Jackson, P. L., Michon, P. E., Geslin, E., Carignan, M., & Beaudoin, D. (2015). EEVEE: the empathy-enhancing virtual evolving environment. *Frontiers in human neuroscience*, *9*, 112. https://doi.org/10.3389/fnhum.2015.00112

Krijn, M., Emmelkamp, P. M., Biemond, R., de Ligny, C. D. W., Schuemie, M. J., & van der Mast, C. A. (2004). Treatment of acrophobia in virtual reality: The role of immersion and presence. *Behaviour research and therapy, 42*(2), 229-239. https://doi.org/10.1016/S0005-7967(03)00139-6

Meyerbröker, K., Morina, N., Kerkhof, G., & Emmelkamp, P. M. G. (2011). Virtual Reality Exposure Treatment of Agoraphobia: a Comparison of Computer Automatic Virtual Environment and Head-Mounted display. *Annual Review of Cybertherapy and Telemedicine*, 51-56.

Loewenstein, G., & Lerner, J. S. (2003). The role of affect in decision making. In *Handbook of affective sciences* (pp. 619-642). New York, NY: Oxford University Press.

Marinier, R. P., Laird, J. E., & Lewis, R. L. (2009). A computational unication of cognitive behavior and emotion. *Cogn Syst Res., 10*(1), 48-69. https://doi.org/10.1016/j.cogsys.2008.03.004

Marsella, S. C., & Gratch, J. (2009). EMA: a process model of appraisal dynamics. *Cogn Syst Res., 10*(1), 70-90. https://doi.org/10.1016/j.cogsys.2008.03.005

Mestre, D. R. (2014). Evaluation of navigation interfaces in virtual environments. *Proc. SPIE 9012, The Engineering Reality of Virtual Reality 2014, 901207* (February 28, 2014). https://doi.org/10.1117/12.20421

Planalp, S. (1996). Communicating emotion in everyday life: cues, channels, and processes. In P. A. Andersen, & L. K. Guerrero (Eds.), *Handbook of communication and emotion* (pp. 29-48). San Diego: Academic Press. https://doi.org/10.1016/B978-012057770-5/50004-7

Rodríguez, L. F., Gutierrez-Garcia, J. O., & Ramos, F. (2016). Modeling the interaction of emotion and cognition in Autonomous Agents. *Biologically Inspired Cognitive Architectures, 17*, 57-70. https://doi.org/10.1016/j.bica.2016.07.008

Rodríguez, L. F., & Ramos, F. (2014). Development of computational models of emotions for autonomous agents: a review. *Cognitive Computation, 6*(3), 351-375. https://doi.org/10.1007/s12559-013-9244-x

Rumbell, T., Barnden, J., Denham, S., & Wennekers, T. (2012). Emotions in autonomous agents: comparative analysis of mechanisms and functions. *Auton Agents Multi-Agent Syst., 25*(1), 1-45. https://doi.org/10.1007/s10458-011-9166-5

Russell, J. A. (2003). Core affect and the psychological construction of emotion. *Psychol Rev., 110*(1), 145-172. https://doi.org/10.1037/0033-295X.110.1.145

Samsonovich, A. V. (2013). Emotional biologically inspired cognitive architecture. *Biol Inspir Cogn Archit., 6*(0), 109-125. https://doi.org/10.1016/j.bica.2013.07.009

Scheutz, M. (2004). Useful roles of emotions in artificial agents: a case study from artificial life. In: AAAI'04: *Proceedings of the 19th national conference on Artificial intelligence* (p. 42-7). AAAI Press.

Scherer, K. R. (2003). Vocal communication of emotion: a review of research paradigms. *Speech Commun., 40*(1-2), 227-256. https://doi.org/10.1016/S0167-6393(02)00084-5

Simon, H. A. (1967). Motivational and emotional controls of cognition. *Psychological & Review, 74*, 29N39. https://doi.org/10.1037/h0024127

Slater, M. (2002). Presence and the sixth sense. *Presence: Teleoperators and Virtual Environments, 11*(4), 435-439. https://doi.org/10.1162/105474602760204327

Slater, M., Usoh, M., & Steed, A. (1994). Depth of presence in virtual environments. *Presence: Teleoperators &*

Virtual Environments, *3*(2), 130-144. https://doi.org/10.1162/pres.1994.3.2.130

Slater, M., Brogni, A., & Steed, A. (2003, October). Physiological responses to breaks in presence: A pilot study. In *Presence 2003: The 6th Annual International Workshop on Presence* (Vol. 157). Citeseer.

Torisu, T. (2016). *Sense of Presence in Social VR Experience*. http://www.interactivearchitecture.org/sense-of-presence-in-social-vr-experience.html

Usoh, M., Catena, E., Arman, S., & Slater, M. (2000). Using presence questionnaires in reality. *Presence: Teleoperators & Virtual Environments*, *9*(5), 497-503. https://doi.org/10.1162/105474600566989

Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. *Presence*, *7*(3), 225-240. https://doi.org/10.1037/t21619-000

Wooldridge, M., & Jennings, N. R. (1995). Intelligent agents: Theory and practice. *The knowledge engineering review*, *10*(2), 115-152. https://doi.org/10.1017/S0269888900008122

Yao, L., Liu, Y., Li, W., Zhou, L., Ge, Y., Chai, J., & Sun, X. (2014, June). Using physiological measures to evaluate user experience of mobile applications. In *International Conference on Engineering Psychology and Cognitive Ergonomics* (pp. 301-310). Springer, Cham. https://doi.org/10.1007/978-3-319-07515-0_31

Ziemke, T., & Lowe, R. (2009). On the role of emotion in embodied cognitive architectures: From organisms to robots. *Cognitive computation*, *1*(1), 104-117. https://doi.org/10.1007/s12559-009-9012-0